STATEMENT OF WORK
Scanning Electron Microscope

Background
The GSFC Detector Development Laboratory (DDL) has a requirement to acquire a scanning electron microscope with electron beam lithography capabilities. The system is used to image micro and nanoscale structures built in the detector development laboratory. The system shall be suitable for secondary electron and backscatter electron imaging. The system shall include all necessary software and hardware to enable electron beam lithography including proximity effect correction software. The provider shall provide technical support of the equipment.

Objectives
The objective of this project is to procure a Scanning Electron Microscope (SEM) with Electron Beam Lithography (EBL) writing capability.

Scope
The scope of this work includes production and delivery of a Scanning Electron Microscope. The SEM which consists of electron optics and detectors, a specimen stage, a vacuum system, an electron beam lithography package, and a workstation required to operate the SEM and EBL is used for high resolution imaging and inspection of micro and nano-scale components. The EBL system will enable nanoscale lithography for increased for printing nano detectors, circuits and devices increasing fabrication capability and improved performance of products manufactured in the DDL. The equipment is essential for nearly all device fabrication projects, especially for technology development projects, taken up by GSFC's Detector System Branch. In particular, the equipment is immediately needed for technology development for the cosmic microwave background polarization technology, microwave kinetic inductor detectors, Far-Infrared Detectors, Large Format Magnetic Calorimeters, and Microfluidic Components which are important to Goddard's lines of business.

No prototypes or one-of-a-kind systems will be considered. The unit must be a production model with at least 5 similar units working in the field.

a) Design of Scanning Electron Microscope at the vendor location.
b) Approval of the design by the GSFC technical representative, communicating requirements to GSFC for installation including electrical power needs, gasses vacuum and other utilities as required.
c) Construction of Scanning Electron Microscope at the vendor facility.
d) Crating and Shipping the unit to GSFC where the vendor's personnel shall install it.
e) Installing, demonstrating, and training, of approximately three GSFC personnel, on the Scanning Electron Microscope at GSFC.
f) Phase II/acceptance testing of the Scanning Electron Microscope at NASA.

Requirements

The Supplier shall provide a new Scanning Electron Microscope (SEM) with Electron Beam Lithography (EBL) capability. The Supplier shall insure that the SEM is equipped with the following equipment and meet the following requirements prior to Acceptance of System:

Scanning Electron Microscope

1. A brand new unit is required; no used equipment or accessories, listed below, are acceptable.
2. Has the capability to meet current industry standard requirements for safety including the use of Emergency Off (EMO) panic buttons, shielding, and interlocks for hazardous areas including high voltages and moving parts.

3. SEM Electron Optics

3.1. SEM gun will be designed to work with tungsten filament (W-filament) and interchangeable LaB6 filament.
3.2. LaB6 optimized high voltage power supply
3.3. Independent ion pumping of the gun and upper column and specimen chamber.
3.4. Imaging scanning modes: high resolution, high depth of focus, large field of view, ultra-low magnification, and beam rocking mode allowing stereoscopic 3D imaging and selected electron channeling. Switching between modes will be fully computer controlled
3.5. Computer controlled electron optics including aperture size and aperture alignment.
3.6. Magnification Range 1 to 1,000,000 or better.
3.7. Accelerating Voltages: 200V to 30kV in 10V steps
3.8. Resolution with Secondary Electron Imaging: High Vacuum mode: 3.0nm at 30kV/2.0nm at 30kV(LaB6), 5nm or better at 3kV(LaB6)
3.9. Probe current 1pA to 2uA.
4.10 Drift in probe current: +/- 0.5%/hr LaB6 filament
4.11 Noise in probe current: W,LaB6 filament < 1%
4.12 Integrated picoammeter with continuous computer display of beam probe current. The SEM software will allow for setting and entering of the beam probe-current to user defined value.
4.13 Full column length Mu-metal shielding.

5 SEM Specimen Stage

5.1 Stage will be fully motorized computer controlled compucentric 5 axis stage (X,Y,Z, Rotation and Tilt) fully compucentric in both tilt and rotation allowing simultaneous changes in tilt and rotation while maintaining the same feature in the field of view.
5.2 Movement continuous: (X = 130mm, Y = 130mm, Z = 100mm, Rotation = 360deg, bidirectional tilt = -30deg to 90deg, 8kg or greater weight capability.
5.3 Fully integrated self- leveling pneumatic vibration isolation.
5.4 Maximum sample height > 115mm with rotation stage

5.5 Stage drift: < 10nm/min after 5min

6 Specimen Chamber

6.1 The specimen chamber internal size will be > 275mm x 300mm internal dimensions and have 12 ports to accommodate the following items:

- Retractable Backscatter Electron Detector
- Energy Dispersive X-ray Detector
- Electrical Feedthroughs
- Vacuum Gauges

7 Vacuum System

7.1 The SEM will have a two stage high vacuum system (a mechanical pump for roughing and backing functions and a turbomechanical pump with oil free magnetic bearings)

7.2 An ion pump is required for the source.

7.3 The SEM chamber and column will remain under vacuum when the system is shut down.

7.4 Pumpdown to operating status < 5min after sample exchange.

7.5 Independent vacuum gauges for monitoring column and chamber vacuum pressures with continuous display of both column and chamber vacuum levels.

7.6 System will have fully automated backing/foreline valve

7.7 Working chamber pressure for high vacuum operation < 6e-5 torr. Low vacuum mode up to 120Pa for W filament and 500Pa with added pressure limiting aperture.

8 Microscope Control and Hardware

8.1 The microscope will be fully computer controlled via a customizable graphical user interface running Microsoft Windows 7 or higher.

8.2 The SEM will be integrated with an optional Control Panel with dedicated knobs for brightness, contrast, probe current, magnification, focus, X,Y stage movement.

9 PC interface

9.1 The SEM will have one PC to control the SEM and will have a 16bit scan generator and store 16k x 16k images.

9.2 All SEM users access will be through independent password protected accounts. All user accounts can be managed by supervisor accounts with control over user priveledges. Each user has a default setup. Operation conditions of the tool are logged separately for each user.

9.3 The SEM will have the following automated operations: Vacuum control, filament heating, gun alignment, aperture alignment, probe current optimized for set spot size, spot size optimized for magnification, contrast and brightness, focus and stigmation, restore image conditions based on image meta-data, Stage movement and stage positioning based on saved image.

9.4 The SEM will allow customized scripting allowing external control and development of user-defined applications and automated operations

9.5 PC will monitor stage control and position and warn the user if samples are close to any integrated accessories (e.g. lenses, detectors) to avoid collisions. This capability will be allowed to be over-ridden based on the user expertise defined in the user account. The software will record any time a user generates a potential collision and any time a user over rides a collision warning.

10 Scanning and Imaging

10.1 The SEM will have the following scanning modes

- Full frame
- Line scan, point (spot)
- Dynamic focus
- Tilt correction
- Depth mode (enhanced depth of focus)
- Field mode (enhance field of view at low magnification)
- Wide field mode (Ultra – low magnification imaging)
- Live Stereo 3D imaging
- Reduced Raster, continuously adjustable size, shape and scan speed on live image.
- Signal mixing function: Different signals from the same field of view can be mixed to produce a combined image.

10.2 Live and saved image formats can be independently defined for each user account . Digital images can be archived in TIFF, JPEG, JPEG2000, BMP, GIF, and PNG formats. All microscope operating conditions are saved in a .txt metafile with each image. All microscop operating conditions including stage position, can be restored from any saved image.

10.3 The SEM will include an integrated image database allowing the user to browse, view or edit or search various images.

10.4 Image store resolution of 16k x 16k.

10.5 Measurement software will be included which allows multiple measurement features on saved or live images including point position, line length, distance between two lines, angle, radius, diameter, area or perimeter of square, rectangle or ellipse. Measurement software will allow use of grey or RGB level intensity to determine feature sizes within the image. Data from measurement shall be easily exported in common formats such as .txt file.

11 Electron Beam Lithography

11.1 The SEM must include electron beam lithography (EBL) capability. The EBL software control will be fully compatible with SEM control software and not provided by an external vendor. EBL will support continuous variable dwell times from 20ns to 10,000us. The EBL software will have full control of the electron beam writing and the stage positioning, beam blanker and integrated picoammeter.

11.2 Sample holders incorporating a Faraday Cup integrated with the SEM pico-ammeter for accurate measurement of beam current will be provided.

11.3 An optional additional license for installation of the EBL software for off-line use for design and setup of EBL jobs. The additional software copy shall be portable and unlocked with a USB key.

11.4 EBL will include the following features

- Single and multiple write fields
- Definition of exposure dose based on beam current and spot size, and pitch.
- Proximity effect correction to beam dose as a function of position and geometry allowing variable exposure time calculated based on pattern shape-to-shape interactions on a defined grid.
- Software compatibility with typical CAD formats including GDSII and DXF.
- Automatic height sensing and stage drift compensation.

12 Integration with other systems

12.1 The SEM will allow complete functional integration with external systems (e.g. EDX, WDX).

13 Remote Operation

13.1 The SEM shall be remotely accessed, controlled and diagnosed via any TCP/IP connections (e.g. LAN, Internet, etc) Remote access will be possible using a secure dedicated client-server model built into the microscope operating software, without requiring any 3rd party remote PC control software. Remote access shall be easily and completely disabled and enabled at the microscope. Remote access connections shall be authenticated to allow access only to specific remote clients.

14 Microscope Diagnostics and Logging

14.1 The SEM will incorporate a comprehensive internal hardware diagnostics system encompassing all SEM subsystems. A complete hardware/software selftest is executed at each user logon. All faults, errors, and unusual conditions or user settings are reported. All selftest results are appended to and permanently saved in log files.

15 SEM Detectors

15.1 The SEM will have an Everhart-Thornley Secondary Electron Detector incorporating a single crystal YAG scintillator

15.2 The SEM will include a continuous retractable backscattered electron detector incorporating a single crystal YAG scintillator. The retraction system must be UHV –compatible. Motorized retraction will be optionally available.

15.3 The SEM will include an infrared chamberscope camera. Operation of the chamberscope camera will be fully integrated with the SEM's graphical user interface, allowing users to view the chamberscope image in a moveable and sizable window on the PC monitor.

16 SEM Beam Blanker

16.1 The SEM will include an electrostatic beam blanker, integrated into the gun of the electron column with 50ns blank/unblank times and 10MHz bandwidth.

16.2 The beam blanker will have 100% blanking of electron beam for accelerating voltages 1kV to 30kV.

16.3 The beam blanker will be fully compatible and automated by electron beam lithography software installed on the PC.

17 Facilities

17.1 The SEM and all required components (PC, vacuum pumps, etc) will operate from standard 120V/60Hz power.

17.2 The SEM does not require any source of cooling water for operations.

17.3 Exterior surface parts shall be clean and free of grease or dust and compatible with operation in a Class 100 cleanroom environment.

17.4 The supplier will provide an optional uninterruptible power supply

18 SEM PC minimum specifications

18.1 Intel I3 dual core processor

18.2 8GB RAM

18.3 500GB HDD

18.4 DVD-RW optical drive

18.5 2GB Graphics card with dual monitor support

18.6 Windows 7 64bit or greater operating system

18.7 24" wide screen or larger LCD monitor, keyboard, mouse and/or trackball.

19 Installation and Training

19.1 The price of the SEM will include installation at GSFC. Installation will include a demonstration that the tool is within compliance with the specifications.

19.2 The price of the SEM must include delivery of the instrument to Goddard Space Flight Center.

19.3 At the completion of installation and demonstration, the successful contractor will provide on-location training at GSFC.

20 Documentation and Warranty

20.1 A full set of all written documentation will be provided. This will include user manuals or equivalent as well as copies of any software, and any manuals for the software included with the system. This documentation shall be received by GSFC with the system hardware.

20.2 The contractor will offer the GSFC at least the same warranty terms, including offers of extended warranties, offered to the general public in customary commercial practice. Warranty terms must be included in the system price. The period of warranty will begin upon acceptance of the system.

The Supplier shall install the system on-site at GSFC's Detector Development Laboratory or another, designated, laboratory in NASA/GSFC's Building 11 and provides operator training of the system. Together with GSFC technical personnel, the Supplier shall review the system, demonstrate and confirm that the system functions properly based on the specifications above.

Supplier shall provide a Warranty of at least 12 Months (Parts and Labor), guaranteed to meet factory specifications.

Installation and training shall be performed by a factory trained technician at NASA/GSFC.

Deliverables or Delivery Schedule
Deliver complete specified (as described above) system. Set up and install all components at GSFC (in Bldg11 or in the DDL).

1. Demonstrate system with specified performance/acceptance criteria (described above). Acceptance of system will be conditional upon successful demonstration of functions.
2. Provide user training for equipment operation.
3. Equipment warranty on parts and labor for at least one year.
4. Operational manuals and maintenance manuals with circuit schematics and layouts.
5. Spare parts including extra sample holders and extra filaments.

Delivery Schedule
Within 20 weeks after award.

Government-Furnished Equipment and Government-Furnished Information
No Government-furnished equipment (GPE) and Government-furnished information (GFI) will be required

Security
The Supplier Representative who will be installing the Scanning Electron Microscope and Training NASA personnel must be a US Citizen

Place of Performance
The Construction of the Scanning Electron Microscope shall be performed at the Supplier's facilities

The Installation and Training shall be performed at NASA/GSFC, Greenbelt, Maryland.